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Editorial

Special Issue "Study of Biodegradation and Bioremediation"

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It is with great pleasure that we present to you the output of the Special Issue Study of Biodegradation and Bioremediation. We are extremely pleased that despite the difficult time of the pandemic, many researchers from all over the world wanted to include their research in our Special Issue.

With regret, it has to be said that despite several regulations and great care for storage and transport safety, there is still the possibility of uncontrolled release of petroleum products, substrates in chemical synthesis, drugs, dyes, etc. Moreover, the currently used solid waste and sewage water management methods do not allow for the effective removal of both persistent contaminants and pharmaceuticals. Ecological disasters, frequently occurring in large sizes and regular waste management, show how important it is to have some appropriate techniques that are helpful in rapid remediation of the environment. The biodegradation of pollutants depends on various factors, such as their chemical structure, physicochemical properties, or bioavailability for microorganisms. Therefore, there is a need to develop new effective bioremediation processes and extensive and deep studies on biodegradation processes conducted by microorganisms.

What is more, a comprehensive and multifaceted look at the phenomena accompanying biological degradation is very important. Work on effective conduct of biodegradation and bioremediation processes has been going on for decades. However, in recent years, new analytical techniques and an intensively developed interdisciplinary perspective on these issues have yielded many valuable results. These have become the core of the articles forming this Special Issue.

We would now like to introduce the publications included in this collection briefly. To begin, we would like to clearly emphasize that neither the order of the mentioned articles nor the amount of text devoted to them proves the value of these publications. In our opinion, each of them is an important and valuable contribution to the development of our knowledge and carries significant application meaning. The first group of articles deal with the removal of petroleum hydrocarbons from the environment.

Yaman's article "Performance and Kinetics of Bioaugmentation, Biostimulation, and Natural Attenuation Processes for Bioremediation of Crude Oil-Contaminated Soils" [1] considered the effectiveness of bioaugmentation and biostimulation in hydrocarbon removal in his paper. In his pilot study, the author noted that the TPH degradation in the crude oil contaminated soil was improved by bioaugmentation with genus Alcanivorax and biostimulation with nitrogen and phosphorus. On the other hand, Smułek et al. focused on the bioavailability of pollutants to cells as a limiting factor for the biodegradation process [2]. Their paper "Modification of the Bacterial Cell Wall-Is the Bioavailability Important in Creosote Biodegradation?" is a significant study showing the complexity of changes occurring on the cell surface and inside cell membranes that are caused by contact of bacteria with PAHs.

The paper by Malachov et al. "Ability of Trichoderma hamatum Isolated from Plastics-Polluted Environments to Attack Petroleum-Based, Synthetic Polymer Films" provides a link between the problem of hydrocarbon contamination and environmental plastic pollution [3]. The results presented here add a great deal to knowledge on the biodegradation of

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plastics by different consortia of microorganisms. Contamination of the environment by heavy metals is a particularly difficult challenge due to their extreme toxicity and bioaccumulation in living organisms. It is, therefore, worthwhile to look at new possibilities for removing heavy metals from soils and waters.

The combination of phytoremediation and microbial remediation was addressed by Garcia-Martin et al. In their paper, "Identification of Copper in Stems and Roots of Jatropha curcas L. by Hyperspectral Imaging." They studied these issues based on an extensive statistical analysis of hyperspectral images in the visible/near-infrared [4]. Moreover, Tsipa et al., in their article "Iron-Stimulated Production and Antimicrobial Potential of a Novel Biosurfactant Produced by a Drilling Waste-Degrading *Pseudomonas citronellolis* Strain," showed the high potential of a peptide biosurfactant produced by a strain of the genus *Pseudomonas* [5]. Thus, these researchers confirm that hydrocarbon-contaminated sites can also become a source of bacterial strains capable of producing valuable compounds from a pharmaceutical and cosmetic perspective.

There is a trend of looking at contaminated sites as a source of interesting microorganisms, including extremophilic ones. As such, the publication "Coal-Degrading Bacteria Display Characteristics Typical of Plant Growth Promoting Rhizobacteria" by Titilawo et al. determines the genetic relatedness of coal-degrading bacterial strains isolated from the rhizosphere of grasses growing on coal discard dumps and from diesel-contaminated sites [6].

Another equally interesting Special Issue thread is research on effective heavy metal remediation. Bravo et al. published a paper, "Effects of Mercury II on *Cupriavidus metallidurans* Strain MSR33 during Mercury Bioremediation under Aerobic and Anaerobic Conditions." Their research indicates that the *C. metallidurans* strain MSR33 they tested may be useful for mercury bioremediation in polluted water under aerobic and anaerobic conditions [7].

The global production of dyes is still increasing, which affects their dispersion in the environment. This problem was addressed by Liu et al. [8]. Their article "Preparation of KOH and H_3PO_4 Modified Biochar and Its Application in Methylene Blue Removal from Aqueous Solution," touches upon the problem of using bio-based materials for methylene blue water treatment. The research of Kolodziejczak-Radzimska and Jesionowski in the article "A Novel Cysteine-Functionalized MxOy Material as Support for Laccase Immobilization and a Potential Application in Decolorization of Alizarin Red S," is significant, as well [9]. These researchers used immobilized laccase to remove alizarin dye, highlighting key technological aspects, including the importance of proper carrier selection in the immobilization process. These studies are referenced in the paper by Nguyen et al. "A Novel Approach in Crude Enzyme Laccase Production and Application in Emerging Contaminant Bioremediation," describing the potential of an enzymatic membrane reactor for the oxidation and removal of emerging contaminants (ECs), such as pesticides, pharmaceuticals and steroid hormones [10].

Also of interest are the results of Ashraf et al. ("Evaluation of Toxicity on Ctenopharyngodon idella Due to Tannery Effluent Remediated by Constructed Wetland Technology"), who highlighted the problem that is tannery effluent water. The specific composition of pollutants poses a problem for aquatic microorganisms, however the use of constructed wetlands is a promising option to reduce pollutant emissions [11]. Last but not least, two review papers round out the Special Issue. Vázquez-Núñez et al., in their swim article "Use of Nanotechnology for the Bioremediation of Contaminants: A Review," provides a broad perspective on using state-of-the-art nanotechnology in bioremediation processes while highlighting the complexity of interactions between microorganisms, nanomaterials, and environmental contaminants [12].

Our collection also could not miss the issues related to environmental contamination with drugs. This topic was taken up by Tripathi et al., who presented the publication "Environmental Remediation of Antineoplastic Drugs: Present Status, Challenges, and

Future Directions" [13]. Although they focused on a specific group of pharmaceuticals, their observations are relevant to the broader issue of removing bioactive compounds.

In closing, we would like to again thank all the authors for their work. Thanks to them, we all gain insight into the latest research on bioremediation and biodegradation processes. We are convinced that this will bring tangible benefits to scientists and society as a whole.

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